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MEMORANDUM FOR PRS (In-House Publication)

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Blanski, Rusty; Phillips, Shawn; Lee, Andre, "The Preparation and Properties of Polymer/Nanoparticle Blends Using POSS™" (VuGraphs)

2001 International Symposium on Nanocomposites **(Statement A)**
(Chicago, IL 25-27 June 2001)(Deadline: 24 June 2001)

The Preparation and Properties of Polymer/Nanoparticle Blends Using POSS™

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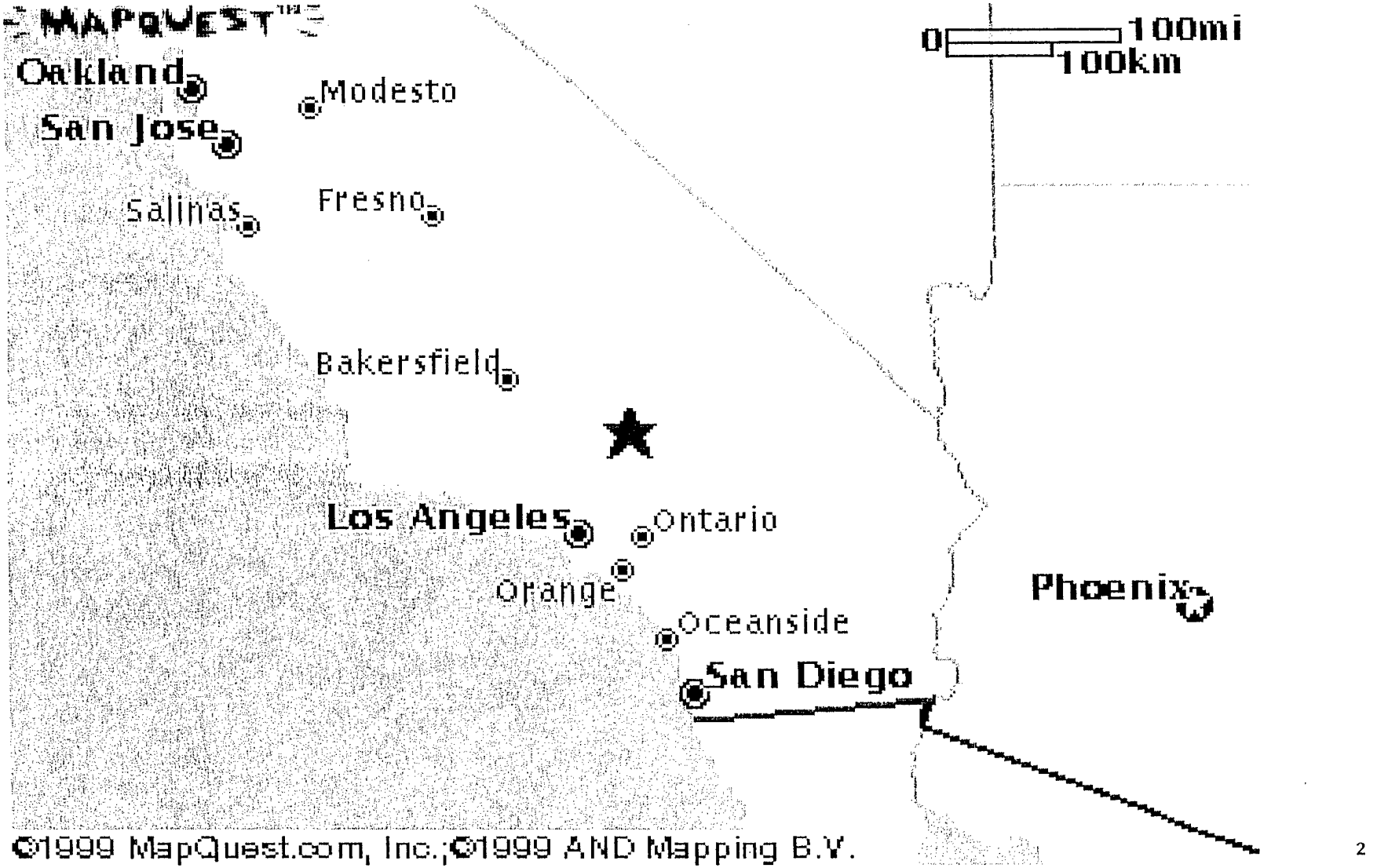
Air Force Research Laboratory

Located ~ 100 miles from LA



POSS/Polymer Blends

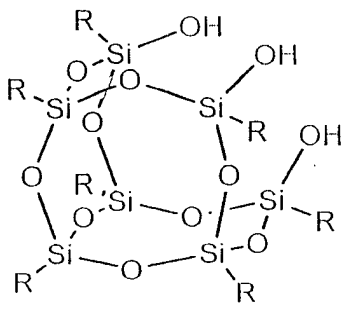
- GOAL: We are looking to increase the use temperatures of polymers by blending in Polyhedral Oligosilsesquioxanes (POSS)
- Several polymers were looked into as candidates for blending: Polyethylene, Polystyrene, Polycarbonate, and Styrene-Butadiene Rubber

Why Use Blendables?

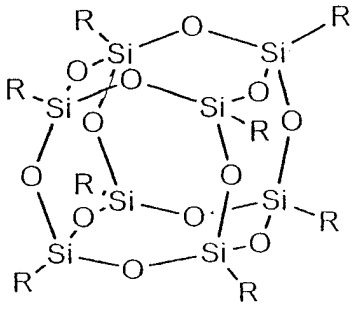
- Easier to tailor the organic side groups of the POSS molecule to give a polymer-soluble species
- Simple blending techniques can be used instead of copolymerization with reactive POSS monomers
- Potential Drop-in molecular modifier without requiring expensive replacement of processing equipment

POSS = Polyhedral Oligomeric Silsesquioxane General Synthesis

R = cyclopentyl
vinyl



R = cyclopentyl



R = cyclopentyl
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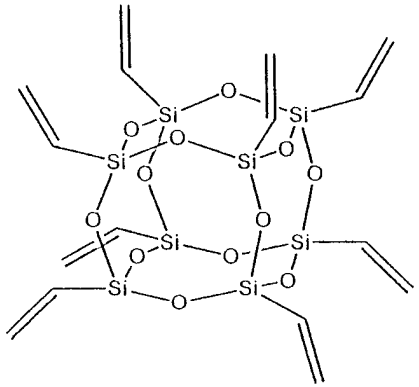
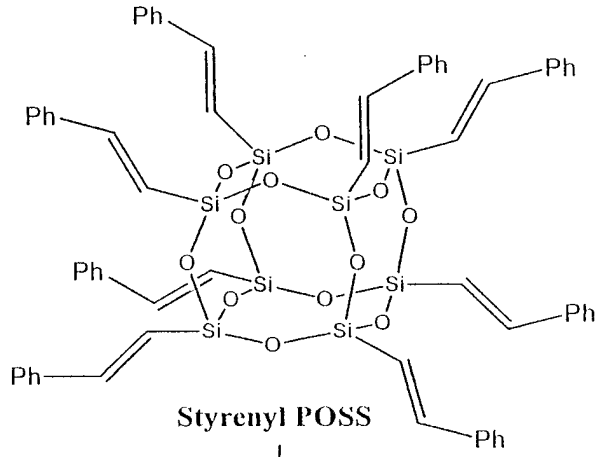


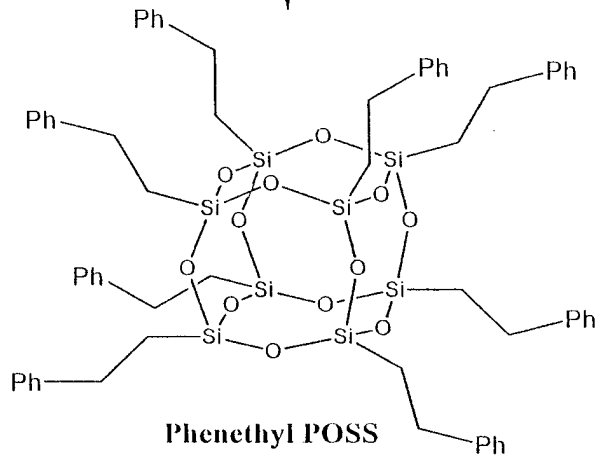
$Cl_2Ru(=CHPh)(PCy_3)_2$

Toluene/Styrene $-C_2H_4$



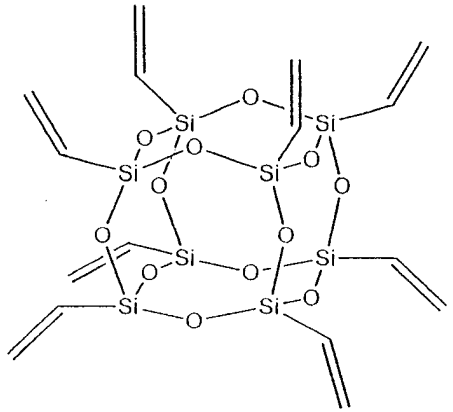
Styrenyl POSS

H_2 Pd/C



Phenethyl POSS

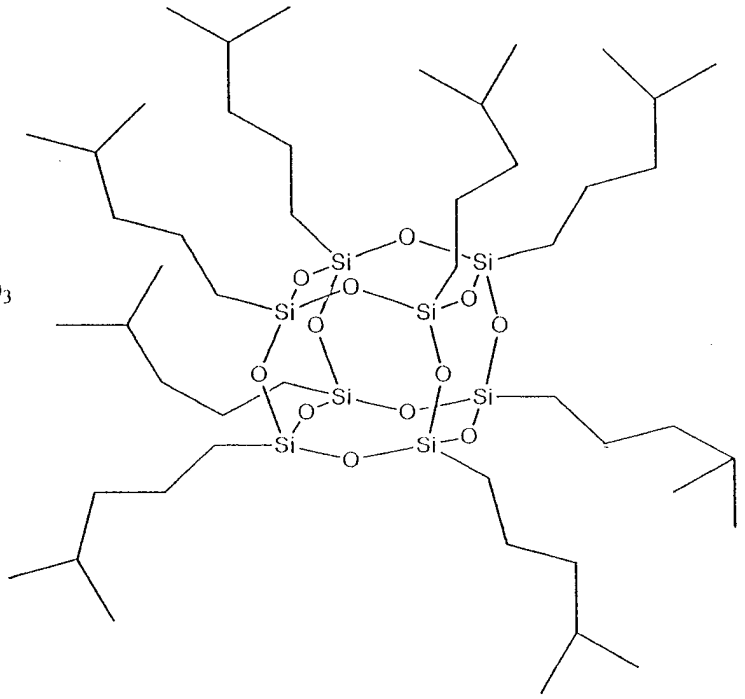
POSS = Polyhedral Oligomeric Silsesquioxane General Synthesis



1. $Cl_2Ru(=CHPh)(PCy_3)_3$

4-MethylPentene, $-C_2H_4$

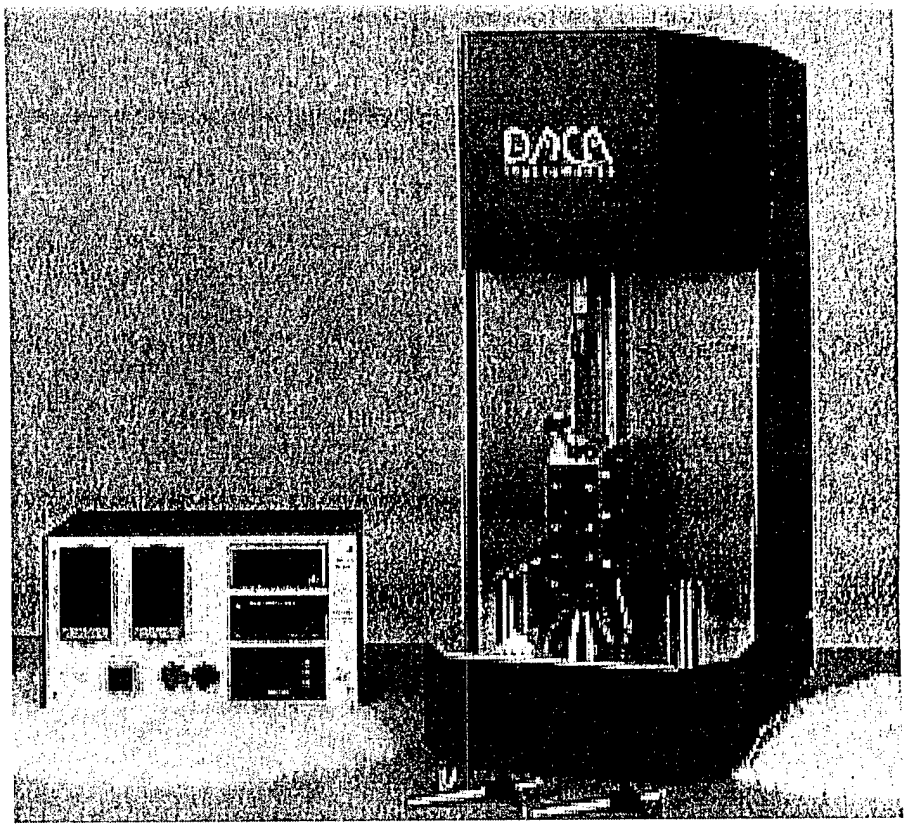
2. Pd/C H_2 500 PSI



4-MP POSS

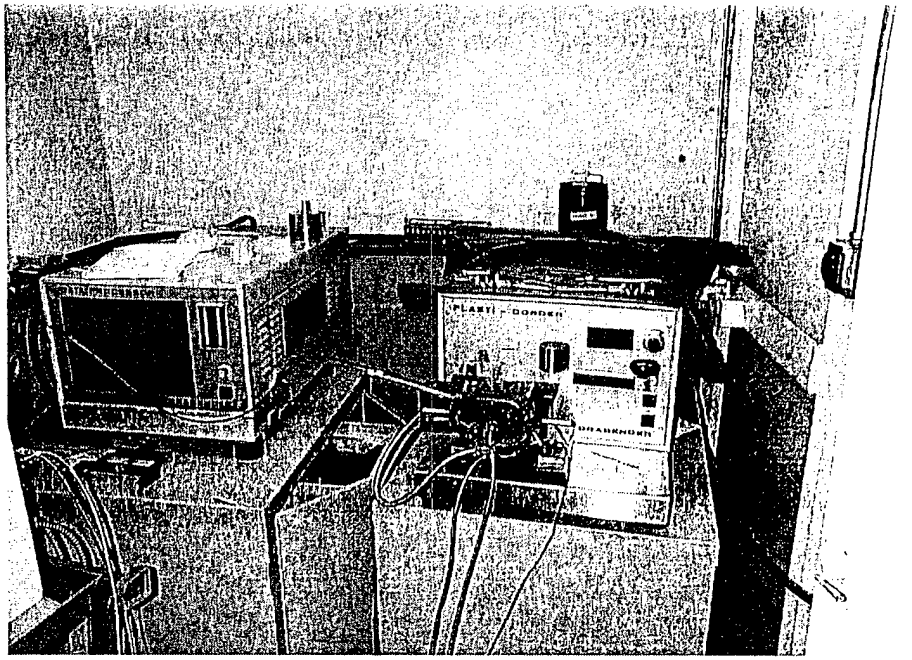
Preparation of Polymer-POSS Blends

- Traditional Processing
- **Place Polystyrene in Extruder**
- **Add POSS**
- **Blend 2-5 Minutes**
- **Use a DACA for small scale (4 g)**



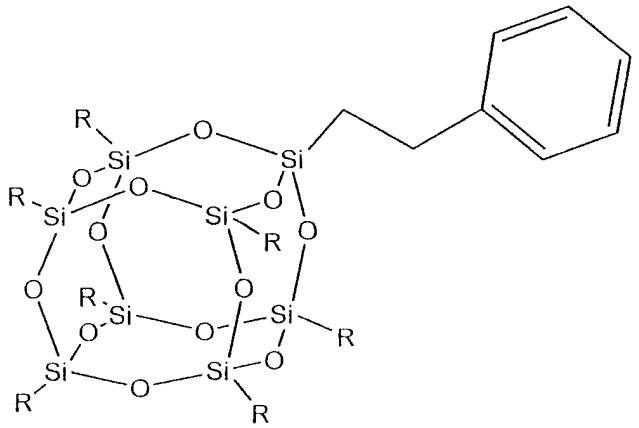
Preparation of Polymer-POSS Blends

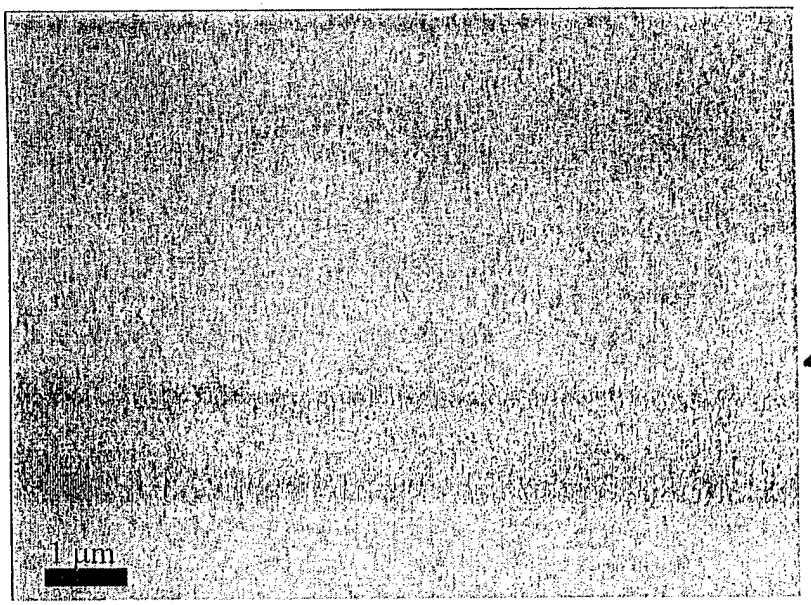
- <u>Traditional Processing:</u>
- <u>Brabender Mixer</u>
- Place Polystyrene in Mixer at temperature
- Add POSS
- Blend 5-10 Minutes
- Grind
- Press into disks/extrude/ injection mold



Miscibility of POSS

50 wt % Phenethyl$_8$T$_8$ in 2 million mol. wt. Polystyrene





← Are there supposed to be black dots on this ?

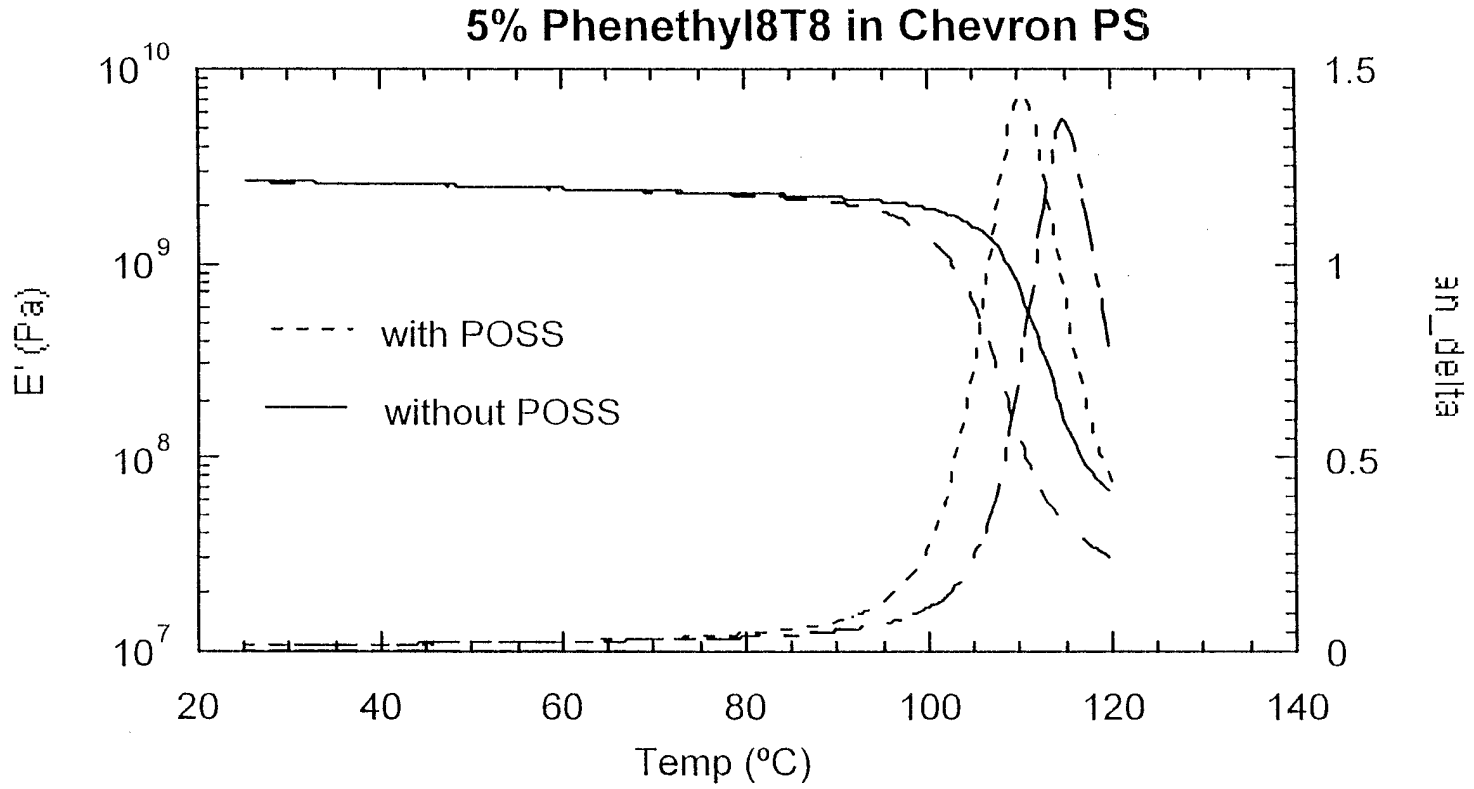
- Demonstrated Complete Miscibility
- Grey domains represent miscible POSS/polystyrene
- Black dots are POSS crystallites (<100 POSS molecules)
- 30% increase in surface hardness observed

POSS-Polymer Blends

Selected Data for POSS-Polymer Blends

Resin	POSS compound	Processing Temp. °C	Appearance
Polystyrene	Phenethyl$_8$T$_8$	177	Clear
BPA polycarbonate	Phenethyl$_8$T$_8$	300	Clear
SB Rubber	Phenethyl$_8$T$_8$	100	Clear
HDPE	Octyl$_8$T$_8$	120	Cloudy
HDPE	4-MP$_8$T$_8$ (**2**)	120	Cloudy

Addition of POSS into PS



No Change in modulus at ambient Temperatures
Small Change in T_g observed

Conclusions

- POSS can be blended and dispersed into many polymers
- The organic side groups on the POSS molecule are extremely important in determining the solubility of the POSS in polymers
- The addition of the more soluble Styrenyl POSS into styrene leads to an increase in surface hardness without adversely affecting polymer properties
- POSS can be thought of as functionalized silicas with the side groups acting as solubility enhancers